end of the lower half of the lake. The water, however, was shallow in this part of the lake, and the records are rather disturbed by local effects due to wind. The periods of the seiches detected here were 20·4 minutes, 11·9 minutes, and 3·3 minutes. The 20·4-minute and 11·9-minute periods are due to the uninodal and binodal seiches of the lower half of the lake. The 3·3-minute period is probably

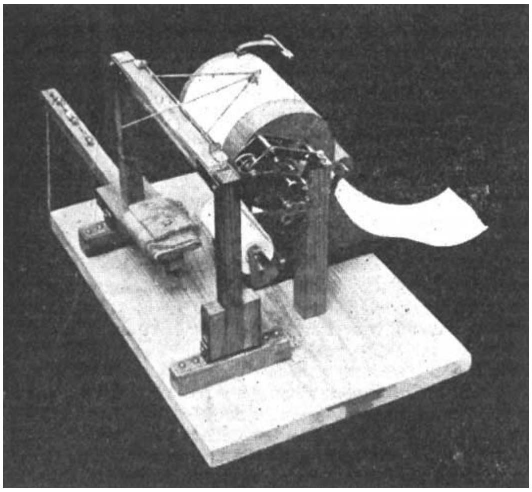


FIG. 1.—Recording Limnograph.

due to a transverse seiche. The maximum range recorded was about an inch.

After this, the recording apparatus was set up at the head of the lake. The upper half of the lake being much deeper than the lower half, better records were obtained. The maximum range recorded was about $1\frac{1}{4}$ inches. The periods here were well marked, and had the following times:—69·7 minutes, due to the uninodal seiche of the whole lake; 14·1 minutes and 6·6 minutes, due to the

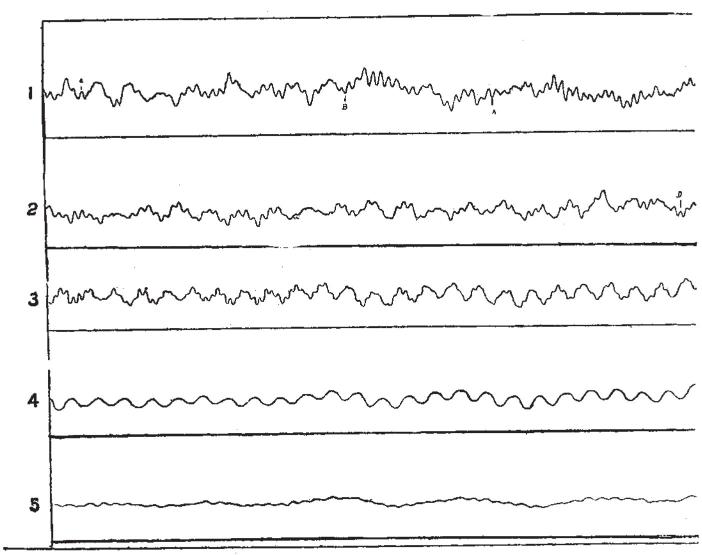


FIG. 2.—Traces obtained at Head of Windermere.

uninodal and binodal seiches, respectively, of the upper half of the lake; also a well-marked, short period of 3·4 minutes. This last period is probably due to the trinodal seiche, and also to a transverse seiche, which has nearly the same period. In some cases, the movement due to this oscillation alone was nearly an inch.

The figure shows some of the traces obtained. Nos. 1, 2, and 3 are typical traces obtained at the head of the lake. Nos. 4 and 5 are obtained from No. 3 by Prof. Chrystal's method of residuation. The 3·4-minute period is seen in the original trace. No. 4 shows the 14·1-minute and 69·7-minute periods, and is obtained by residuating out the 3·4-minute and 6·6-minute periods. No. 5 shows the 6·6-minute and the 69·7-minute periods, after the 3·4-minute and the 14·1-minute periods have been residuated out. In Nos. 1 and 2 the rate of movement of the paper was one inch in 18·8 minutes, and in No. 3 one inch in 23·2 minutes.

During the later experiments a form of apparatus was used which proved quite satisfactory, and, being simple to construct, may be worth briefly describing. A strip of paper, from a continuous roll fixed on the base of the instrument, passes up and over a horizontal wooden cylinder, 3 inches in diameter, and driven by clockwork. After passing half-way round the cylinder, the paper passes under a small roller carried on springs. This roller presses the paper against the wooden cylinder, and, since the paper passes half-way round the cylinder before passing under the roller, there is no possibility of it slipping.

A horizontal lever is pivoted to the base of the instrument, one end of which projects outwards, and is connected to the float by a string, while the other end carries a weight. The pen and holder are carried by a horizontal rod, which is supported by two upright arms, being fixed to them at each end by pivots. One of these arms is fixed to the lever, at the place where it is pivoted to the base of the instrument, while the other arm is pivoted direct to the base. As the float moves up and down, this horizontal rod moves backwards and forwards, parallel to the axis of the wooden cylinder. On the horizontal rod are bearings, which carry the light frame holding the pen, which rests on the top of the wooden cylinder. When the lever is half-way up or down, the bearings of the pen are about the same height as the top of the wooden cylinder, then, as the float moves the lever up and down, the pen moves in an almost straight line across the paper on the top of the cylinder.

This apparatus is simple to construct, and, since the only friction is in the pen and the four pivots, the whole system moves very freely, and a float 5 inches in diameter will work it easily, while Chrystal's "waggon" recorder requires a 10-inch float. GORDON DOBSON.

Caius College, Cambridge, April 19.

The Flight of Exocœtus.

PRACTICAL difficulties will prevent the settlement of the question as to whether or no a flying fish supports itself by movement of its fins by the method suggested by a correspondent in NATURE of February 9, viz. kinematograph photography.

Anatomy and phylogeny converge to the support of those observers who declare that the "wings" are motionless during "flight."

(1) Any resemblance to the huge musculature of birds is out of the question, but if the wings vibrate to any purpose, something resembling in scale the muscular and nervous specialisation found in insects should obtain here. Has anything of the sort been found? On the contrary, the muscular development of Exocœtus is, like that of other fish, directed to propulsion by the tail.

(2) The structure and habits of the lower members of the family, Hemiramphus and Belone, indicate stages in the evolution of Exocœtus. The former is able to make great leaps nearly parallel to the surface, of such force, indeed, that the natives here tell me of men who have been pierced by the elongated lower jaw two inches deep in the flesh of the leg when wading among them. "When it is out of the water it is quite mad and strikes whatever is in the way, whether a man or a boat, and so kills itself," to quote their description.

Belone can almost fly, its effort having the appearance of running on the surface on the tip of its tail, suggesting some use of this member, but not of the normal-sized fins, in extending the range of "flight." These two steps in the evolution of the habit of Exocœtus distinctly lead to the

idea of a parachute leap, but do not at all support an evolution of flight by beating wings.

Exocœtus is the natural parallel of the aëroplane, which, it is hoped, will rise from and descend upon water with ease and perfect safety. The flying fish, however, frequently strikes a wave with one fin and is overturned, or strikes it with violence. It would be very interesting to know whether Belone does aid itself by its tail, and so is in some way a parallel to the hydroplane boat.

CYRIL CROSSLAND.

Dongonab, Port Sudan, Red Sea, March 24.

The Stinging Tree of Formosa.

WITH reference to the letter on the Stinging Tree of Formosa in NATURE of March 2, it would be interesting if your correspondent would throw light on the exact mechanism by which the sting in *Laportea pterostigma* and *L. crenulata* is produced. *L. crenulata* is locally abundant in some parts of India. The curious point is that the leaves are often glabrous. Moreover, the stinging effects are, apparently, sometimes experienced without actual contact with the plant. I was one day walking through the hot, steaming forests near the Tista River, in British Sikhim, with a friend. The Laportea was abundant, and we carefully avoided it. On our way home my friend was seized with the peculiar stinging sensations of the Laportea in several parts of his body. These lasted several days, and on the night immediately after being stung became so bad that he was unable to get any rest and became feverish.

On another occasion I had to cut a survey line through dense forest with an undergrowth of *L. crenulata*. The coolies avoided the leaves as much as possible, and cut the stems low. Some of them were stung on the body, but all were attacked in different degrees with sneezing, violent catarrh, and ultimately vertigo. I myself, although at some distance from the actual cutting operations, though I had to walk up the cut line, suffered to a less degree in the same way. Yet I have often dashed a leaf across the back of my hand with no ill effects! Sir J. Hooker and others have noted that the effects are worse at some times of the year than at others. The inflorescence, it should be noted, is covered with hairs, and I have only been able to account for the facts above described by supposing that it is these deciduous hairs of the inflorescence which get into the clothes and become inhaled when the tree is shaken.

H. H. HAINES.

Camp, Central Provinces, India, March 24.

Fundamental Notions in Vector Analysis.

I SHALL be much obliged if you will kindly permit me, through the columns of NATURE, to make some suggestions regarding fundamental conceptions in vector analysis, a subject which was vigorously discussed in this journal about twenty years ago (NATURE, vols. xliii., xliv., xlvii., xlviii., xlix.). The discussion showed that the slow progress of vector analysis was in a large measure due to the want of unanimity as to its fundamental notions and notations, and to an unfortunate aspect peculiar to it, viz., a strong conviction on the part of the advocate of any one of the various systems of vector analysis, that the other systems, if allowed to grow, will do more harm than good, while it may be noticed that in our ordinary scalar analysis, although several systems (*e.g.* Cartesian, polar, pedal, trilinear, &c.) exist side by side, there is no such feeling. My object now is to suggest a system which, while it aims at a reconcilement between the various systems, will contain the best features of each of these known systems.

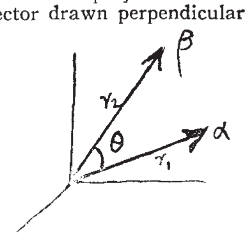
Dr. Knott (NATURE, vol. xlvii., p. 590) justifies the introduction of the quaternion as a fundamental conception by saying that it is only a generalisation to the case of vectors of the quotient (in the case of scalars) of two lengths. But a great objection is that the quaternion—a hybrid conception, in part a scalar and in part a vector—is not *by itself* capable of being defined in terms of the three fundamental entities, magnitude, direction, and position, as every *fundamental* conception ought to be. No such thing can, however, be said of the fundamental notions of the non-quaternionists, the scalar product and the vector product, which are defined in terms of only the fundamental notions of geometry and trigonometry. I may also repeat an argument of Prof. Gibbs (NATURE, vol. xlvii., p. 463) that the introduction of the scalar product and the vector product as fundamental conceptions will meet Prof. McAulay's observation (*Ph. Mg.*, vol. xxxiii. 1892, p. 477) that the arrest in the development of vector analysis is due to the circumstance that quaternions are "independent plants that require separate sowing and consequent careful tending." Besides, as is pointed out by Prof. Gibbs (NATURE, vol. xliii., p. 511), it is not desirable that the simpler conceptions should be expressed in terms of those which are by no means so. It is not sufficient to say, as has been argued (Heaviside, NATURE, vol. xlvii., p. 533), that vector analysis should have a purely vectorial basis; for that would only be a play of words.

Now, although the non-quaternionists thus avoid certain initial difficulties in presenting the subject, some of them, viz., Mr. Heaviside and Prof. Macfarlane, have made innovations which not only have no justification, but have created insuperable difficulties. We must have $\alpha^2 = -1$, and we must recognise the versional character of the vector; the principles of vector algebra must differ as little as possible from the principles of scalar algebra, and we cannot be blind to the usual meaning of equations such as $ij = k$, &c., as was pointed out by Dr. Knott (NATURE, vol. xlviii., p. 148; vol. xlvii., p. 590). All these difficulties and others have arisen from an attempt to oust the conception of a quaternion, whether in the initial or at any later stage. So supreme is the contempt that Gibbs, while dealing with the theory of dyadics, regards $\alpha\beta + \lambda\mu + \gamma\nu$, a sum of expressions analogous to the quaternions, as indeterminate, merely symbolic, having physical meaning only when used as operator, although scalars and vectors are derived from it.

It is unfortunate that the advocates of vector analysis cannot work in harmony with one another, recognising superiority of each other in particular respects. Although Gibbs admits that the quaternionic method has advantages in certain cases, he would not tolerate its existence in the field of vector analysis, or rely upon it in places where he has found advantages.

With regard to the question of notations, I may refer to NATURE, vol. xlvii., p. 590, where Dr. Knott rightly says that the symbols used by the quaternionists for the scalar product and the vector product express at once and clearly the nature of the functions they represent, and that it is not proper to use the sign of ordinary multiplication in a case which does not admit of one of the factors being carried over to the other side as a divisor.

I shall now work out the successive stages of introducing the proposed system. We shall begin with the scalar product, $S\alpha\beta$, and the vector product, $V\alpha\beta$, defining the former as a quantity equal to minus the product of the length of one of the vectors, α, β, and the projection on it of the other, and the latter as a vector drawn perpendicular to the plane of the vectors, of a length equal to the area of the parallelogram determined by them, so that rotation round it from α to β through an angle less than 180° is positive. We see that we shall have



$$S\alpha\beta = S\beta\alpha, \quad V\alpha\beta = -V\beta\alpha.$$

Now if we take $\alpha = ix_1 + jy_1 + kz_1$

$\beta = ix_2 + jy_2 + kz_2$

we have,

$$\begin{aligned} S\alpha\beta &= -T\alpha T\beta \cos\theta \\ &= -T\alpha \times \text{ projection of } T\beta \text{ on } \alpha \\ &= -\left[r_1 . x_2 . \frac{x_1}{r_1} + r_1 . y_2 . \frac{y_1}{r_1} + r_1 . z_2 . \frac{z_1}{r_1} \right] \\ &= -(x_1x_2 + y_1y_2 + z_1z_2 \end{aligned}$$

$$\begin{aligned} V\alpha\beta = \; & i \text{ (projection of area of parm. } \alpha, \beta \text{ on } x \text{ plane)} \\ & + j \text{ (projection of area of parm. } \alpha, \beta \text{ on } y \text{ plane)} \\ & + k \text{ (projection of area of parm. } \alpha, \beta \text{ on } z \text{ plane)} \\ = \; & (y_1 i_1 z_2 - y_2 z_1) + j(z_1x_2 - z_2x_1) + k(x_1y_2 - x_2y \end{aligned}$$

$$\begin{aligned} \therefore \; S\alpha\beta + V\alpha\beta &= -(x_1x_2 + y_1y_2 + z_1z_2) + i(y_1z_2 - y_2z_1) + j(z_1x_2 - z_2x_1) + k(x_, y_2 - x_2y_1) \\ &= (ix_1 + jy_1 + kz_1)(ix_2 + jy_2 + kz_2) \\ &= \alpha\beta. \end{aligned}$$